

In the Claims:

1. (currently amended): A scheduling control system for a switch having a Virtual Output Queue comprising:

a request information management unit managing the number of scheduling requests and holding forwarding request information of each input line as a scheduling target with respect to a desired output line;

an inter-highway pointer control unit for indicating a start-of-scheduling input line;

an intra-highway pointer control unit for indicating a start-of-retrieval output line in the forwarding request information corresponding to each input line; and

a scheduling processing unit for starting the retrieval of the output lines from the output line indicated by said intra-highway pointer control unit according to the forwarding request information, selecting the output line unselected by other input lines, performing the scheduling for all the input lines in sequence starting from the input line indicated by said inter-highway pointer control unit, and updating each start-of-retrieval output line indicated by said intra-highway pointer control unit at a next scheduling cycle, whereby said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines.

2. (currently amended): A scheduling control system for a switch having a Virtual Output Queue comprising:

a request information management unit managing the number of scheduling requests and holding forwarding request information of each input line as a scheduling target with respect to a desired output line;

an inter-highway pointer control unit for indicating a start-of-scheduling output line;

an intra-highway pointer control unit for indicating a start-of-retrieval input line in the forwarding request information corresponding to each input line; and

a scheduling processing unit for starting the retrieval of the input lines from the input line indicated by said intra-highway pointer control unit according to the forwarding request information, selecting the input line that is not ensured by other output lines, performing the scheduling for all the output lines in sequence starting from the output line indicated by said inter-highway pointer control unit, and updating each start-of-retrieval input line indicated by said intra-highway pointer control unit at a next scheduling cycle, whereby said schedule processing unit executes arbitration such that a scheduling result does not compete between lines.

3. (previously presented): A scheduling control system according to claim 1, wherein said scheduling processing unit updates an inter-highway pointer to a next adjacent line per scheduling cycle, and updates an intra-highway pointer to a next line adjacent to the line with forwarding determined.

4. (previously presented): A scheduling control system according to claim 1, wherein said scheduling processing unit updates an inter-highway pointer to a line next to the line

with the forwarding established at first within the scheduling cycle, and updates an intra-highway pointer to a next line adjacent to the line with the forwarding determined.

5. (previously presented): A scheduling control system according to claims 1, wherein said scheduling processing unit, if the request information exists in the line indicted by the intra-highway pointer and this line is used by other lines, does not update the intra-highway pointer.

6. (currently amended): A scheduling control system for a switch having a Virtual Output Queue comprising:

- a request information management unit managing the number of scheduling requests and holding forwarding request information of each input line as a scheduling target with respect to a desired output line;

- an inter-highway pointer control unit for holding an inter-highway pointer for indicating a start-of-scheduling input line;

- an intra-highway pointer control unit for holding an intra-highway pointer for indicating a start-of-retrieval output line in the forwarding request information corresponding to each input line;

- a request management control unit for holding forwarding request information to a desired output line; and

- a scheduling processing unit for starting the retrieval of the output lines from the output line indicated by said intra-highway pointer control unit based upon plural pieces of the forwarding request information, and selecting the output line

unselected by other input lines, and after finishing the scheduling, updating the inter-highway pointer to an adjacent line by alternately executing between a process of updating to an adjacent line in a forward direction per scheduling cycle, and a process of updating to an adjacent line in a reverse direction, whereby said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines.

7. (previously presented): A scheduling control system according to claim 1, wherein said scheduling processing unit includes:

means for dividing, when selecting the forwarding request information corresponding to each line as a scheduling target, the forwarding request information into two pieces of information before and after the intra-highway pointer, and obtaining the lines having lowest numbers based on a low number selection logic from those pieces of information; and

means for obtaining a final forwarding line number from the obtained two lower number lines with a priority given to a result after the intra-highway pointer.

8. (previously presented): A scheduling control system according to claim 1, wherein a plurality of said scheduling processing units are provided, and said scheduling control system further comprises pipeline processing means for each independently executing a pipeline process.

9. (currently amended): A scheduling control system for a switch having a Virtual Output Queue comprising:

a request information management unit managing the number of scheduling requests and holding forwarding request information on each input line as a scheduling target with respect to a desired output line;

an inter-highway pointer control unit for holding an inter-highway pointer for indicating a start-of-scheduling input line;

an intra-highway pointer control unit for holding an intra-highway pointer for indicating a start-of-retrieval output line in the forwarding request information corresponding to each input line;

a request management control unit for holding forwarding request information to a desired output line; and

a plurality of scheduling processing units for starting the retrieval of the output lines from the output line indicated by said intra-highway pointer control unit from plural pieces of the forwarding request information, and selecting the output line unselected by other input lines, said scheduling processing unit executing arbitration such that a scheduling result does not compete between lines, and

wherein said plurality of scheduling processing units further include a plurality of pipeline processing means having inter-highway pointers with different start-of-scheduling line numbers and each independently executing a pipeline process, and

said intra-highway pointer control unit is independently controlled per said pipeline processing means.

10. (currently amended): A scheduling control system for a switch having a Virtual Output Queue comprising:

a request information management unit managing the number of scheduling requests and holding forwarding request information on each input line as a scheduling target with respect to a desired output line;

an inter-highway pointer control unit for holding an inter-highway pointer for indicating a start-of-scheduling input line;

an intra-highway pointer control unit for holding an intra-highway pointer for indicating a start-of-retrieval output line in the forwarding request information corresponding to each input line;

a request management control unit for holding forwarding request information to a desired output line; and

a scheduling processing unit for starting the retrieval of the output lines from the output line indicated by said intra-highway pointer control unit from plural pieces of the forwarding request information, and selecting the output line unselected by other input lines, whereby said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines, and

wherein said scheduling processing unit further includes a load observing unit for counting the number of packets arrived within a fixed cycle per logical forwarding request information of each input line, and performs the scheduling of a next cycle in accordance with the number of packets counted by said load observing unit.

11. (original): A scheduling control system according to claim 10, wherein said scheduling processing unit restricts the number of forwarding permission packets to each

output line within the fixed cycle, to the number of arrived packets to each piece of logical forwarding request information at the previous cycle.

12. (original): A scheduling control system according to claim 10, wherein said scheduling processing unit determines a rate for attaining a top priority output line in the scheduling within the fixed cycle in accordance with the number of arrived packets at the previous cycle.

13. (original): A scheduling control system according to claim 12, wherein said scheduling processing unit holds a top priority forwarding pointer, other than the intra-highway pointer, for determining the line for forwarding with a top priority in accordance with the number of arrived packets at the previous cycle, determines the output line in accordance with a rate of the number of arrived packets to each piece of the forwarding request information in accordance with the top priority forwarding pointer with respect to the number of all the arrived packets arrived at the input line at the previous cycle, and executes the scheduling with respect to those excluding the number of all the arrived packets in accordance with the normal intra-highway pointer.

14. (previously presented): A scheduling control system according to claim 10, wherein said scheduling processing unit executes, if the packets, of which the number is the same as the number of arrived packets at the previous cycle, are not forwarded within a present cycle, a process of carrying over a remaining number of arrived packets to the number of arrived packets at a next cycle.

15. (original): A scheduling control system according to claim 10, wherein said scheduling processing unit determines a rate for attaining a top priority output line in the scheduling within a fixed cycle in accordance with a forwarding request information length at the previous cycle.

16. (previously presented): A scheduling control system according to claims 10, wherein there are constructed extension units each including said scheduling processing unit per input line, two pieces of I/O ports, a selector unit for switching over an external I/O and an internal ring-connection, and a delay unit capable of changing a forwarding delay quantity to an extension output, and said extension units are ring-connected.

17. (currently amended): A scheduling control system for a switch having a Virtual Output Queue comprising:

means for notifying a scheduling processing unit of a quality of service (QoS) class together with forwarding request information;

a scheduling processing unit for executing a scheduling process based on the forwarding request information on a first priority class of each input line in a first scheduling, and for executing, with an output line being unestablished in the first scheduling, the scheduling based on the request information on a second priority class, whereby said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines,

wherein said scheduling processing unit includes:

a scheduler for managing the number of scheduling requests and performing the scheduling from a higher priority class among two or more classes; and a buffer for executing band control of the output line determined by said scheduler and intra-group band control.

18. (previously presented): A scheduling control system according to claim 17, wherein said scheduling processing unit further includes notifying means for notifying said buffer of a result of scheduling after the scheduling with respect to the first priority class and a buffer band control unit for controlling the band of the QoS class within the line determined by said scheduler and performing delay priority control,

said buffer, if within a predetermined band of the QoS class, accepts a result given from said scheduler and forwards data accumulated in said buffer, and, if out of the band, makes the forwarding request information thereof invalid and notifies said scheduler of this purport, and

said scheduling processing unit thus performs a second scheduling.

19. (currently amended): A switch having a Virtual Output Queue comprising:

means for notifying a scheduling processing unit of a QoS class together with forwarding request information;

a scheduling processing unit having a scheduler for executing scheduling in order to determine an output line based on the forwarding request information, whereby said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines;

an input buffer for controlling a band of the output line determined by said scheduler; and

a band control unit for executing delay and band control of each QoS class in the output line having a forwarding right determined in said scheduling processing unit, reading packet-formatted data from said buffer if within a predetermined band, and, if out of the predetermined band, notifying said scheduler of a purport that the forwarding request information is invalid without outputting the packet-formatted data from said buffer.

20. (currently amended): A packet device with a Virtual Output Queue comprising:

means for notifying a scheduling processing unit of a QoS class together with forwarding request information;

a scheduling processing unit for executing a scheduling process based on the forwarding request information on a first priority class of each input line in a first scheduling, and for executing, with an output line being unestablished in the first scheduling, the scheduling based on the request information on a second priority class, whereby said scheduling processing unit executes arbitration such that a scheduling result does bit compete between lines,

wherein said scheduling processing unit includes: a scheduler for executing scheduling in order to determine an output line based on the forwarding request information and performing the scheduling from a higher priority class among two or more classes; and

a buffer for controlling a band of the output line determined by said scheduler and intra-group band control,

wherein said scheduling processing unit further includes notifying means for notifying said buffer of a result of scheduling after the scheduling with respect to the first priority class and a buffer band control unit for controlling the band of the QoS class within the line determined by said scheduler and performing delay priority control,

said buffer, if within a predetermined band of the QoS class, accepts a result given from said scheduler and forwards data accumulated in said buffer, and, if out of the band, makes the forwarding request information thereof invalid and notifies said scheduler of this purport, and

said scheduling processing unit thus performs a second scheduling.

21. (previously presented): A scheduling control system according to claims 17, wherein said scheduling processing unit gives a forwarding right to the forwarding request in an arbitrary off-band QoS class if unable to obtain the forwarding right in any QoS classes under the band control.

22. (currently amended): A band control system for executing band control for a switch having a Virtual Output Queue, comprising:

means for notifying a scheduling processing unit of a QoS class together with forwarding request information;

a scheduling processing unit having a scheduler for executing scheduling in order to determine an output line based on the forwarding request information,

whereby said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines;

a buffer, divided in logical output routes, for controlling a band of the output line determined by said scheduler;

an individual counter, provided per line or per QoS class, for counting leaky buckets with respect to the output line selected by said scheduler; and

a representative counter, provided per line, including an internal timer and for counting an elapsed time since the output line has been selected last time,

wherein said each representative counter holds a time when the selection of the last time is made on the basis of said internal timer, and obtains the elapsed time by making a comparison with a present time when the selection is made next time.

23. (cancelled):

24. (currently amended): A scheduling control system for a switch having a Virtual Output Queue comprising:

a request information management unit managing the number of scheduling requests and holding forwarding request information on each input line as a scheduling target with respect to a desired output line;

a scheduling processing unit, having N-pieces (N is a natural number equal to or more than 2) of priority patterns with different selection priorities between the respective output lines, for selecting the output line unused by other input lines in accordance with the priority pattern and the forwarding request information, whereby

said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines; and

a priority pointer control unit for indicating a start number of the priority patterns,

wherein said scheduling processing unit sequentially performs the scheduling for the N-patterns from the priority pattern indicated by a priority pointer, and updates the start number of the priority patterns at a next scheduling cycle.

25. (previously presented): A scheduling control system for a switch having a Virtual Output Queue comprising:

a request information management unit managing the number of scheduling requests and holding forwarding request information on each input line as a scheduling target with respect to a desired output line;

a scheduling processing unit, having N-pieces (N is a natural number equal to or more than 2) of priority patterns with different selection priorities between the respective input lines, for selecting the input line unused by other output lines in accordance with the priority pattern and the forwarding request information; and

a priority pointer control unit for indicating a start number of the priority patterns,

wherein said scheduling processing unit sequentially performs the scheduling for the N-patterns from the priority pattern indicated by a priority pointer, and updates the start number of the priority patterns at a next scheduling cycle.

26. (previously presented): A scheduling control system according to claim 24, wherein said scheduling processing unit applies a random array of inverted LSB/MSB of binary notation permutation layout patterns as the above priority patterns.

27. (previously presented): A scheduling control system according to claim 24, wherein said scheduling processing unit includes means for selecting the forwarding line in accordance with the priority indicated by the priority pattern, and means for making a rotation of a combination of input line numbers and output line numbers which are different between the respective lines at every scheduling cycle.

28. (previously presented): A scheduling control system according to claim 24, wherein said scheduling processing unit includes a scheduler for determining a selection candidate within a small group having a plurality of priority patterns with different selection priorities between all the lines, and an arrangement scheduler for arranging the candidates selected by said scheduler in accordance with the priorities between all the lines, and determining the final line.

29. (previously presented): A packet switch having a Virtual Output Queue comprising:
sorters each serving as a unit sorter for sorting input cells coming from m-lines of input routes and transferring the sorted input cells to m-lines of output routes, said packet switch being constructed by connecting said unit sorters at multi-stages,

wherein outputs per said unit sorter of a first-stage unit sorter group are outputted separately to a dummy sorter provided at a second stage and said unit sorter at the second stage,

outputs of said second-stage dummy sorter and of said second-stage unit sorter are inputted to a third-stage unit sorter group, and

N-input/N-output sorter network is configured on the whole by connecting $(2N/m-1) \times N/m$ pieces of said unit sorters.

30. (previously presented): A packet switch having a Virtual Output Queue comprising:

sorters each serving as a unit sorter for sorting input cells coming from m-lines of input routes and transferring the sorted input cells to N-lines of output routes, said packet switch being constructed by connecting said unit sorters at multi-stages in matrix in X- and Y-directions,

wherein outputs of said respective unit sorters are inputted to next-stage unit sorters positioned in (+)X- and (-)Y-directions of said unit sorter,

when extending said sorter group, the outputs of said respective unit sorters are inputted next-stage unit sorters positioned in the (+)X-direction of said unit sorter, and

an N-input/N-output sorter network is configured on the whole by connecting $N/m \times (N/m+1)/2$ pieces of said unit sorters.

31. (currently amended): A packet switch having a Virtual Output Queue comprising:

a request information management unit managing the number of scheduling requests and holding forwarding request information on each input line as a scheduling target with respect to a desired output line;

an inter-highway pointer control unit for holding an inter-highway pointer for indicating a start-of-scheduling input line;

an intra-highway pointer control unit for holding an intra-highway pointer for indicating a start-of-retrieval output line in the forwarding request information corresponding to each input line;

a request management control unit for holding forwarding request information to a desired output line; and

a scheduling processing unit for starting the retrieval of the output lines from the output line indicated by said intra-highway pointer control unit from plural pieces of the forwarding request information, and selecting the output line unselected by other input lines, whereby said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines,

wherein said scheduling processing unit, after allocating the output line numbers to valid cells coming from the respective input lines, allocates dummy output line numbers for idle cells to the input lines to which the valid cells are not allocated, and transfers the output line numbers of the cells coming from all the input lines with different values without any overlaps.

32. (currently amended): A packet switch having a Virtual Output Queue comprising:

a request information management unit managing the number of scheduling requests and holding forwarding request information on each input line as a scheduling target with respect to a desired output line;

a scheduling processing unit, having N-pieces (N is a natural number equal to or more than 2) of priority patterns with different selection priorities between the respective output lines, for selecting the output line unused by other input lines in accordance with the priority pattern and the forwarding request information, whereby said scheduling processing unit executes arbitration such that a scheduling result does bit compete between lines; and

a priority pointer control unit for indicating a start number of the priority patterns,

wherein said scheduling processing unit, sequentially performing the scheduling for the N-patterns from the priority pattern indicated by a priority pointer and updating the start number of the priority patterns at a next scheduling cycle, simultaneously allocates the output line numbers to the valid cells coming from the respective input lines and allocates dummy output line numbers to idle cells by effecting contention control, and transfers the output line numbers of the cells coming from all the input lines with different values without any overlaps.

33. (previously presented): A packet switching method for a switch having a Virtual Output Queue comprising, in a scheduling process of updating an inter-highway pointer indicating a start-of-scheduling input line to a next adjacent input line at every scheduling cycle, and updating an intra-highway pointer indicating a start-of-retrieval output line to a

line adjacent to the line with the forwarding determined on the basis of forwarding request information corresponding to the input line, the steps of:

- imparting a sequence number to a phase-synchronization-oriented cell transferred from each input line;
- sequentially incrementing the output line number;
- shifting the output line number at the same timing between the respective input lines; and
- executing phase synchronization at a cell level by comparing a timing of receiving the phase-synchronization-oriented cell with the sequence number at each lattice point on the switch side.

34. (previously presented): A packet switching method for a switch having a Virtual Output Queue comprising, in a scheduling process of updating an inter-highway pointer indicating a start-of-scheduling input line to a next adjacent input line at every scheduling cycle, and updating an intra-highway pointer indicating a start-of-retrieval output line to a line adjacent to the line with the forwarding determined on the basis of forwarding request information corresponding to the input line, the steps of:

- transferring in broadcast the cells given the sequence numbers to respective lattice points within said switch from the respective input lines; and
- executing phase synchronization at a cell level by comparing the sequence numbers of the arrived cells at the lattice points within said switch.

35. (previously presented): A packet switching method for a switch having a Virtual Output Queue comprising, in a scheduling process of updating an inter-highway pointer indicating a start-of-scheduling input line to a next adjacent input line at every scheduling cycle, and updating an intra-highway pointer indicating a start-of-retrieval output line to a line adjacent to the line with the forwarding determined on the basis of forwarding request information corresponding to the input line, the steps of:

transferring the cells to the respective lattice points within said switch from the input lines; and

adjusting a phase difference at a cell level by a phase adjustment buffer provided at each lattice point.

36. (previously presented): A scheduling control system according to claim 2, wherein said scheduling processing unit includes:

means for dividing, when selecting the forwarding request information corresponding to each line as a scheduling target, the forwarding request information into two pieces of information before and after the intra-highway pointer, and obtaining the lines having lowest numbers based on a low number selection logic from those pieces of information; and

means for obtaining a final forwarding line number from the obtained two lower number lines with a priority given to a result after the intra-highway pointer.

37. (previously presented): A scheduling control system according to claim 2, wherein a plurality of said scheduling processing units are provided, and said scheduling control

system further comprises pipeline processing means for each independently executing a pipeline process.

38. (previously presented): A scheduling control system according to claims 18, wherein said scheduling processing unit gives a forwarding right to the forwarding request in an arbitrary off-band QoS class if unable to obtain the forwarding right in any QoS classes under the band control.

39. (previously presented): A scheduling control system according to claim 25, wherein said scheduling processing unit applies a random array of inverted LSB/MSB of binary notation permutation layout patterns as the above priority patterns.

40. (currently amended): A scheduling control system for a switch having a Virtual Output Queue comprising:

a request information management unit holding forwarding request information for each input line as a scheduling target with respect to a desired output line;

an inter-highway pointer control unit for indicating a start-of-scheduling input line for a scheduling cycle;

an intra-highway pointer control unit for indicating, for each input line, a start-of-retrieval output line in the forwarding request information; and

a scheduling processing unit for starting the scheduling cycle according to the start-of-scheduling input line and retrieving output lines, for each input line, starting from the start-of-retrieval output line, said scheduling processing unit scheduling output

lines based upon the forwarding request information for each input line and selecting the output line unselected by other input lines, performing the scheduling for all the input lines in sequence, and updating each start-of-retrieval output line indicated by said intra-highway pointer control unit at a next scheduling cycle, whereby said scheduling processing unit executes arbitration such that a scheduling result does not compete between lines.